

USE OF ROCK IN EROSION CONTROL PROJECTS

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R.P. Stone and D. Hilborn, Engineering Resources Unit, Resources Management Branch

Rock and stone are used as components in many erosion control systems. They normally absorb the erosive energy in the water and dissipate this energy to the base below.

TYPES OF EROSION CONTROL SYSTEMS REQUIRING ROCKS OR STONES

- (1) **Rock Chute.** This structure uses stones to drop a medium volume of water from one elevation to another. It is usually used in conjunction with a grassed waterway or open ditch.
- (2) **Watercourse Lining.** This lining protects the sides and bottom of the watercourse to prevent erosion or allow for a higher flow. Also, steeper sideslopes and narrower channels can be considered. Slumping prevention, due to side seepage, is another use of a watercourse lining.



Figure 1. Stone used as a watercourse lining providing corner protection.



Figure 2. Stones used as filler in gabion baskets.

- (4) **Low Level Crossings.** Rocks or stones often are used to prevent erosion from vehicle access through the bottom of a watercourse.
- (5) **High Stress Area Protection.** Rocks or stones are used to prevent erosion in specific locations such as under tile drainage outlets, around ditch bank corners, beside drop structure inlets or on emergency spillways.

ADVANTAGES

- (1) Full protection occurs right after installation. No establishment period is required as is the case for vegetative linings.
- (2) Stone has some ability to heal itself. If a stone is moved because of excessive erosive energy, often replacement stones will roll in from a higher elevation.
- (3) Rocks or stones have the ability to shift or float with base or foundation movements. This eliminates any voids which may cause increased stress on the system.
- (4) Stone may be the most economically viable structure, especially if properly sized and shaped stones are available locally.

DISADVANTAGES

- (1) If the rocks or stones have to be transported from a long distance, the cost can become prohibitive.
- (2) Sometimes it is hard to specify and obtain a specific type of stone.
- (3) Movement of rocks or stones from truck access point to the project can be expensive and could cause compaction especially under wet conditions.
- (4) High drops, greater than 1.5 meters (5 feet), usually can't be handled by a rock system.

SIZING ROCKS OR STONES

Two methods are used to determine and specify stone sizes.

- (1) **Diameter.** The most common method is to grade rocks or stones according to diameter. Many Ontario Quarries have stone available in gradients ranging from 50mm (2") in size to 250mm (10"). Larger stone (often called armour rock) normally is available by special order. Smaller sized stone is available, however, its use in erosion projects is very limited.
- (2) **Weight.** Weight is sometimes used in grading or specifying stone size. However, in many cases, the relationship between weight and diameter is required to design and complete a project. Table 1 gives an approximate conversion.

Table 1. Relationship between Diameter and Weight for Angular Shaped Rocks

Diameter		Weight	
mm	in	kg	lb
50	2	0.25	0.5
100	4	2	4
150	6	7	15
200	8	16	35
250	10	34	75
300	12	50	110

Assumptions Used

- rock density of 2400 kg/m³ (150 lb/ft³)
- rock is cubic in shape
- dimension is approximately 10% less than diameter specified

SHAPE OF THE ROCKS AND STONES

Most rocks or stones used in erosion projects are angular or jagged in shape. This is important to ensure that the stones will "knit" themselves together. This "knitting" action will tend to tie the rocks together as a system. If a high erosive force is encountered on one component (ie. rock) the force will be distributed by this action to the whole system.

Rounded stones commonly found on most farm fields will not be effective in most erosion projects. If they are used, special provisions will be required to ensure that they work effectively.

Broken concrete can substitute for rocks or stones provided that they have an angular shape and a size relatively similar to the rock size required. This concrete must be resistant to weathering, frost action and water action. Additional debris such as reinforcing rods should be removed or accounted for in the design.

The rocks, stones or concrete should not have a breadth or thickness less than one-third of its length.

GRADATION OF STONES

A dense mass of well graded randomly placed angular shaped stones has been proven to be much superior to a mass of large stones with correspondingly large voids. In other words it is important that a range of stone sizes be used in a project. This will fill the voids and ensure that the stones will "knit" themselves together.

To specify a gradation one first has to select a D₅₀ which stands for the median stone diameter. In other words 50% of the total weight of stone will have a size greater than the D₅₀ and 50% of the total weight will have a size smaller than the D₅₀. This D₅₀ is usually used to order the stone size (see previous section on stone size).

Table 2 shows the approximate ratios of size required to give a good gradation.

Table 2. Gradation of Rock and Stone

Size of Stone	Percent of total weight smaller than the given size
3K	100
2K	80
K	50
0.1K	10

K is the specified D₅₀ size
From Ministry of Transport and Communications article on Rock RipRap 1978

The above table states that, for example, if a D₅₀ rock= 200mm (8") or 16 kg (35lb) is required, 10% of the rocks will weigh 1.6kg (3.5lb) or less, 50% of the rocks should weigh 16kg (35lb) or less, 80% of the rocks should weigh 32kg(75lb) or less and all the rocks should weigh less than 48kg (105lb). One must always remember that this is only an ideal gradation. In actual practice it is impossible to obtain this exact gradation, therefore, one can only strive to get as close as possible.

DETERMINATION OF THE MEDIAN STONE DIAMETER (D₅₀)

Other publications, available from the Ontario Ministry of Agriculture and Food, have charts relating stone size to the waterflow expected.

PLACEMENT OF THE STONE RIPRAP

Studies by the United States Corps of Engineers have shown that hand placed riprap was not any better than an equivalent thickness of dumped and shaped riprap. Therefore, placement methods should depend on the size of job, access of equipment and availability of necessary labor.

THICKNESS OF A LAYER OF STONE RIPRAP

Usually the thickness of a riprap layer should be 1.5-2.0 times the diameter of the largest stone size but not less than 0.5m (18"). If the individual design specifies a different thickness it should be followed.

FILTER MEDIA

A filter medium is normally required under the stone riprap to prevent losses of the base material caused by surface or ground water flow through the riprap. This medium can either be a granular filter layer or a synthetic filter fabric.

MAINTENANCE REQUIREMENTS

Maintenance of stone or rock structures is required to ensure a long life expectancy. Steps should be as follows.

- (1) Inspect the structure frequently especially after a large storm. Check to see if any movement of the rock has taken place. The void created by the displaced or shifted rock may have been filled by rocks rolling in from a higher elevation. If this has occurred the rock bank at the top of the structure will have to be refilled

periodically. Also, one must watch for voids in the rocks which have not been refilled. If these occur regularly changes should be made to the structure before complete failure occurs.

- (2) Watch for foundation or base movement. This is usually caused by a poorly placed or damaged filter material. Often another filter cutoff will have to be installed to prevent water from tracking under the filter material.
- (3) Take care of other erosion and/or drainage systems above and below this structure. Failure of these may cause failure of the rock structure due to undermining, siltation or increased flow.

ASSISTANCE

Qualified erosion control contractors and consulting engineers are available for assistance in the design and construction of erosion control structures. Conservation Authorities may offer technical assistance and construction supervision in some areas of the province. Other erosion control factsheets and information are available at the local offices of the Ontario Ministry of Agriculture and Food.

All erosion control projects must comply with existing legislation, i.e. Lakes and Rivers Improvement Act, Fisheries Act, etc.

Financial Assistance may be available from the Ontario Ministry of Agriculture and Food or other government agencies. Make sure that all necessary criteria of the grant are satisfied both before and during construction.

